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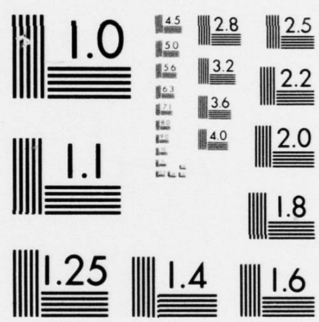

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SERIAL EXPERIMENTATION FOR THE MANAGEMENT AND EVALUATION OF COMMUNICATIONS SYSTEMS

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SERIAL EXPERIMENTATION FOR THE MANAGEMENT AND EVALUATION OF COMMUNICATIONS SYSTEMS*

When there is a decision to mount a demonstration of new communications systems in the field, controversy about the role of evaluation often results. Those who have operational responsibility for the system become its advocates, believing it to be sufficiently robust to succeed. They resent research that would divert resources from the central purpose of demonstrating success. In contrast, evaluators anticipate the chance of failure. They maintain that it is essential to construct systematic and rigorous research on a project so that future projects can learn from past experiences.

The conflict is likely to intensify when the demonstration is underway and something starts going wrong. Project personnel will quickly want to make changes, trying to correct the difficulty. Such action is clearly detrimental to the evaluator's efforts since the more rigorous their design, the more irrelevant the data usually will be if the program has been continually altered. But try, as an evaluator, to persuade a program manager that he or she should leave a failing field program unaltered so that you can rigorously establish the reason for failure in a final report.

One approach to this problem which serves the purposes of both program advocates and evaluators is to use a research design that consists of a series of short experiments that can mutate through successive generations. The manager is committed to holding each discrete, experimental intervention constant, permitting rigorous evaluation. The evaluator is committed to providing the results of each experiment to the manager before the sequential experiment is launched, and being prepared to design new instruments--however imperfect--on the spot to evaluate this change. The manager receives superior planning data in return for periodic inaction and concomitant anxiety.

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To serve these purposes, a field project should have four elements: serial experiments, a process measure, a robust outcome measure, and a standard of comparison. The process measure is essential to understanding how the system actually operates so that the manager can be given guidance on how to direct change. The outcome measure should be tied to a broad goal that will remain relevant despite a variety of system changes so that one can determine the relative value of each system generation. The standard of comparison is essential to a discussion of the value of replicating the system and the generalizability of the results.

Having these factors in a project design has almost no disadvantages, and provides many opportunities to learn from demonstrations even when the starting assumptions are found to be in error. There are, of course, many times when the single, grand experiment is the only feasible route, but it seems likely that many opportunities to establish serial experiments are missed.[1] Here we report on the results of using this logic in the Spartanburg two-way cable project.

The Spartanburg Interactive Cable Education Program

Since February 1975, a two-way cable project has been underway in Spartanburg, South Carolina, that compares the progress of students who use simple home terminals to participate interactively in televised instruction with the progress of students who receive conventional classroom instruction. This effort is part of a program of research supported by the Research Applied to National Needs (RANN) program of the National Science Foundation on the costs and benefits of two-way cable television systems, systems that can be used both to send and receive signals from a home, agency, or business. Research described here is one of several education and training programs conducted in Spartanburg designed to test the value of alternative forms of return communications on a cable system.

Interactive cable television offers a technological opportunity for education that lies somewhere between conventional educational television (ETV) and computer-assisted instruction (CAI). Like ETV, students watch

[1] Segmented time series data can often be used in lieu of serial experiments, providing many of the same advantages.

teachers on a television set and the programs are designed to make heavy use of visual and workbook materials. Like CAI, the students have data terminals that they use to record answers to the teachers' questions and assigned exercises. With interactive cable, however, the students' answers are immediately corrected and reinforced by a teacher rather than by a computer. This not only benefits the students by providing human as opposed to machine feedback, but it also enables the teacher on cable television to have continuing information about the progress of each student readily available as the class proceeds.

In this experiment, adult education at the high school level was chosen as the substantive content to test the value of two-way cable to the home. Using the two-way capacity, Spartanburg Technical College has offered a series of home-based adult education classes using an interactive cable television system in English grammer, reading, and mathematics, the three subjects necessary to prepare students for the General Educational Development (GED) examination for a high school equivalency degree. The text material has been the Cambridge GED series and the content of the course is similar to that of many GED programs around the country. In this demonstration project, the progress of students in the conventional classroom setting is compared with that of students in the "electronic classroom" who view classes from their homes. Each of these students has available an 8-button hand-held terminal to respond to questions posed by the television teacher during a class period.

Students in the electronic classes can use their terminals for three distinct kinds of student-teacher interactions. The most formal interaction is the quiz or question period. In this mode, the teacher asks multiple choice questions from a workbook and the students punch in what they believe to be the correct answers. After a brief pause, the teacher enters the correct answer through the terminal and calls up a display on a CRT mounted in a lectern. She can easily read a list of the student names, the answers they punch, and the aggregate number of right and wrong answers. These results are also recorded in the computer memory so that at the end of the class the teacher has a hard copy of all student responses as well as various summary statistics that aid in an assessment of individual student progress.

In addition to questions posed in the question mode, the teacher can initiate many informal questions, such as questions related to procedures and student understanding of formal course content. Thus the students can be asked to indicate whether they found an exercise to be too difficult, or whether they have completed an in-class problem that has been assigned. A teacher wishing to receive this kind of information from students can switch the system to a second, informal mode. The switch commands the system logic to display student responses for the teacher but not to record these responses in the diagnostics being compiled in the computer memory.

The system also has been designed to allow for student as well as teacher-initiated communications. When the teacher is not asking questions, she can put the system into a third mode. Then when a student hits a button his or her name and an alphanumeric message appear on the teacher's CRT instead of a number for a multiple-choice response. In the current system, the student can send seven messages. These are "I understand" (indicating the student is ready to move on), "slow down," "give an example," "ask a question" (so I can see if I understand), "visuals are unclear," "I don't understand" (so please repeat and review), and "call me" (on the telephone). Each of these messages is printed on the student terminals by the appropriate button. Even though these messages are not a total substitution for the rich array of both verbal and nonverbal cues and messages that a student sends to a teacher in a conventional classroom, they do provide students with a means to communicate with the instructor with respect to how the material is being received. Like the other interactive capabilities, this capacity for student initiated signals was built into the system to make the experience in the electronic classroom as similar as possible to that in the regular classroom setting.

Verbal communication was also possible in later classes. The telephone was not used in the first class, but it was available in subsequent course offerings. A student could call the teacher--and be heard over the system by the rest of class should the teacher choose to lead a general discussion. Telephone use was occasional and supplemental in nature.

Standard of Comparison

The demonstration has been structured so that the program can be evaluated relative to conventional classroom education. Each day, two teachers instruct the class, and their schedules are rotated so that both classes receive equivalent instruction. On a typical day, the math teacher, for example, instructs her class over cable from 8:30 to 10:00 a.m. and then drives to Spartanburg TEC where she teaches a regular class from 10:30 until noon. The reading teacher has the reverse schedule, instructing the conventional class at TEC until 10:00 a.m., and starting the same reading lesson over cable at 10:30 a.m. The curriculum is highly structured and is geared toward preparing students for the type of question that appears on the GED exam. A large portion of each class is devoted to students working on and discussing the answers to workbook problems and exercises that are similar to those on the State GED examinations. Both classes were offered 4 days a week for 15 weeks, a total of 180 hours of instruction. In sum, students in both cable and traditional classes receive the same amount of instruction in the same subjects from the same teachers on the same days. This arrangement enables us to compare the effectiveness of interactive cable education in the home with conventional education in the classroom while holding many factors constant.

Outcome Measure

The basic evaluation measure for this study was the Adult Basic Learning Examination (ABLE), a standardized test of educational achievement. The measure stood out because it had acceptable reliability, and came in two versions for a pretest-posttest evaluation. Moreover, ABLE was the only technically sound examination that had been normed on an adult population. This would enable us to compare the scores of the Spartanburg cohorts entering the program with those of a national sample of adults with similar educational backgrounds. This was important because it helped us establish the extent to which the skill levels of students in our experiment were similar to the skills of this type of student in other parts of the nation. Being able to show that the Spartanburg students are not atypical permits us to generalize the results of our study to other adult populations.

Need for Process Information

But if one is to provide the manager some guidance on the experiment, it is also necessary to provide insight into the ongoing communications process. We therefore felt it was necessary and important to supplement the outcome data with process information that focused on the instructional dynamics of the cable and conventional classrooms. This process information could serve at least three different roles in the demonstration.

First, the process information would help us precisely describe the nature of the cable "classroom" and enable us to understand how the two-way technology affects the pedagogical process. By comparing systematic classroom observation data from both the conventional and cable settings, we could establish how the move to cable had altered such aspects of instruction as organization of time, the nature of class activities, and patterns of classroom interaction.

Second, by providing a tool that would help us adapt the organization of content and teaching styles to the potential of the technology, the process information would be useful in project management. We did not assume that the instructional dynamics we would observe were necessarily those that had to be. In some cases the data we collected might suggest that teachers were not taking full advantage of the technology. Our observations would enable us to offer inservice training that was targeted at particular problem areas. However, if such training failed to result in a realization of the potential of the technology, we would have to entertain the notion that teachers are not able to satisfactorily transfer their teaching styles to the two-way cable setting. Such a finding would have important implications for our assessment of the educational potential of the electronic classroom concept.

Third, the data from the observations could be used to help us understand and explain differences in group outcomes if they occurred. In the event that student achievement in two-way cable class was poor, we needed to know enough about the dynamics of each teacher's style, level of interaction, and use of class time to identify possible remedies. Alternatively, if the cable class did well relative to the conventional group, it would be beneficial to document the teaching style that had contributed to this outcome.

The Observation Instrument. These three uses of process information led to our decision to develop a classroom observation instrument that would permit us to compare the nature of the cable and conventional classes. The underlying approach of the instrument was to focus on those areas where one might expect to find important differences between the cable and conventional classes and that would either indicate that the teachers were not making full use of the interactive dimension of the system or that the conventional and cable classrooms were proceeding quite differently from one another.

The instrument was designed to focus on two distinct areas of classroom pedagogy, the observation of the distribution of classroom activities (the activity record) and observations of the frequency of classroom interactions (the interaction record). Events falling in either of the two areas are coded continuously in order to present a moving record of the instructional dynamics in the respective classes.

The activity record is a system of categories used to code the number of minutes devoted to different activities. The classroom activity variables (Figure 1A) are simply descriptors of the types of activities the students and teachers are engaged in at any given time. The coder is responsible for tracking both the order in which those activities take place and the amount of time devoted to each activity. These variables were intentionally defined so they would be grouped to distinguish along three different dimensions that we believed to be of potential importance in comparing the instruction available to students in conventional and electronic settings.

The first dimension contrasts activities that involve subject matter development with activities not related to the instructional focus of the course. For instance, in a math class a period of time may be characterized by the teacher lecturing on how to solve quadratic equations or by students working at their desks on word problems. Both of these activities involve the "substance" of the course--the teaching of mathematics to students. In contrast, time spent on such activities as equipment adjustment or discussion of how the final grades will be determined (i.e., procedural information) is not considered relevant to the substantive purpose of the class.

A second way of comparing activities is by the extent to which they reflect an interaction between the teacher and students. Several of the

Teacher Substantive Presentation: The classroom activity is characterized by the teacher giving a presentation or explanation intended to convey subject-matter-related information.

Classroom Substantive Discussion: The classroom activity is characterized by verbal interactions between pupils or the teacher and pupils on the subject matter content being presented by the teacher.

Individual Work Period: The classroom activity is characterized by students working individually on assigned work.

Drill and Substantive Drill: The classroom activity is characterized by the teacher asking students narrow questions --that is, questions requiring one or two word replies or yes-or-no answers; questions requiring specific responses. If, during the drill, the teacher either repeatedly asks students to explain how they arrived at their answers or the teacher interrupts the drill to substantially expand the answers, the activity is coded *Substantive Drill.*

Procedural Information: The classroom activity is characterized by the teacher giving and/or students eliciting instructions or information *not* directly related to subject matter content.

Student Dominated Activity: The classroom activity is characterized by an individual student making a presentation to the class.

Examination or Quiz: The classroom activity is characterized by students taking a quiz or examination on which they will receive a grade or other written evaluative feedback.

Equipment Adjustment: The classroom activity is characterized by efforts to adjust the cable equipment.

Teacher Works w/Subgroup: The classroom activity is characterized by the teacher intentionally separating out a subgroup of students with whom to work. (I.e., the teacher acknowledges that certain students need special help and therefore gives other class members something to do so she can work intensively with those students needing special help.)

Non-designated Activity: The class is engaged in activities other than those designated in the other activity categories.

Figure 1A: Brief Description of the Activity Record Categories

The CLOSED Category: A closed question is coded when the teacher asks a question about the subject under study for which the student(s) are to select the answer from a given list of alternatives.

The OPEN Category: An open question is coded when the teacher asks a question about a subject under study for which the student(s) must provide an answer without the benefit of having several response alternatives before them to choose from.

The UNDERSTAND Category: The understand category is used to code a) teacher questions aimed at determining whether students understand or are clear on subject matter related content that has been gone over in class and b) student initiated questions or comments that reflect the extent to which the student understands subject matter related material that has been covered in class.

The ROUTINE Category: The routine category is used to code teacher and student initiated questions that are procedural (as opposed to substantive) in nature.

The RHETORICAL Category: The rhetorical category is used to code questions that are not intended to elicit a response. Rhetorical questions are generally a reflection of a teacher's speaking style.

Figure 1B: Brief Descriptions of Categories in the Interaction Record

activity variables have been included that indicate a high degree of student-teacher interaction. For instance, drill and substantive drill are characterized by the teacher repeatedly asking questions of students. Likewise, for classroom substantive discussion to be coded, there must be evidence of student's questions and comments being frequently interspersed during a teacher's presentation. In contrast, other activities such as individual work and teacher substantive presentation are only coded when the activity in the classroom is characterized by little or no interaction between the teacher and the students.

The third dimension for grouping the activity variables is concerned with whether or not the activity represented by the variables can appear in both the cable and conventional settings. Some of the activities such as drill, individual work period or teacher substantive presentation can be coded in either the cable or conventional classroom. Others such as classroom substantive discussion and student dominated activity can only take place in the traditional classroom. Similarly, equipment adjustment only makes sense in the context of the cable classroom. By including these variables, we can determine the extent to which teachers are prevented from translating aspects of their traditional teaching styles to the cable setting by virtue of the fact that the cable setting will not accommodate some activities. Similarly, we can determine how great a role the unpredictable demands of the technology play in contributing to the differing experience of students in the cable and conventional settings.

The second part of the classroom observation instrument is the interaction record. It deals with the nature and number of teacher and student initiated questions. The observer uses this portion of the instrument to keep an ongoing record of the types and frequencies of questions asked in the classroom. The observer also notes whether the questions are directed at a specific individual or at the class as a whole. Figure 1B presents criteria for coding different interaction variables.

The interaction variables in this second category system have been defined with distinct contrasts in mind that are similar to those previously described for the activity variables. On one level, the variables distinguish between those questions that relate to the subject matter content being studied (i.e., the open, closed, and understand questions) from those that deal with class procedures (i.e., the routine questions). On another level, the variables can be used to distinguish those interactions that can take place in either the cable or conventional classroom (e.g., the asking of closed-ended question or questions of understanding) from those that can only occur in the conventional class (e.g., the asking of an open-ended question, or the occurrence of student-student interaction or teacher-student interaction during an individual work period). In addition, several variable categories require that the coder keep track of those instances where the teacher asks students to explain some aspect of their response. Such an explanation is clearly not possible over the cable system.

Measuring the Impact on the Teaching Process

The results of the first classroom observation records showed clearly that the pedagogical process over interactive cable differs dramatically from that of the traditional classroom. Based on a sample of over 100 ten minute observation periods, both of the cable instruction and the conventional classroom, major differences were evident (Table 1). Note that teachers devoted 18.2 percent of the conventional classroom time to substantive classroom discussion. Of course, there was no opportunity for substantive classroom discussion over cable, and thus a central question was how the teachers sought to compensate for that loss of time. It was not by extending lectures, for the amount of time devoted to substantive presentation was relatively constant, 12.0 percent of classroom versus 13.1 percent over cable. The difference instead appeared in the amount of time devoted to individual student work. While the teachers had the students working individually on problems at their desks 29.7 percent of the time in the classroom, the proportion rose to an alarming 59.8 percent with the cable classes.

The interaction records also showed the impact of the technology. The absolute frequency of interactions in the cable classroom dropped off to one-third of the total interactions in the traditional setting. Norming the data to estimate the average number of interactions in a 90-minute class period, we found that the teacher addressed the classroom students with questions about 138 times per class, compared to 45 times per cable class. The number of routine procedural questions was not very different, but there

Table 1

DISTRIBUTION OF ACTIVITIES AND INTERACTIONS BY CONDITION

Distribution of Activity Time	Classroom	Cable
Teacher Substantive Presentation	12.0%	13.1%
Classroom Substantive Discussion	18.2	0.0
Individual Work	29.7	59.8
Drill	0.0	0.6
Substantive Drill	24.7	17.5
Procedural Information	9.3	7.2
Student-Dominated Activity	0.0	0.0
Exam	0.0	0.0
Equipment Adjustment	0.0	1.0
Teacher Works with Subgroup	1.6	0.0
Nondesignated Activity	4.5	0.8
Total	100.0%	100.0%
Frequency of Interactions per Class	**Classroom**	**Cable**
Closed-ended Questions	14.0	17.4
Open-ended Questions	35.2	0.0
Questions about Understanding	47.6	9.8
Procedural Questions	13.8	12.7
Rhetorical Questions	12.9	5.4
Student Dominated Activity	14.8	0.0
Total Frequencies	138.3	45.3
Total Minutes of Observation	519	494

was a marked decline in the number of questions about student comprehension of the material, as well as a decline in rhetorical questions. While the cable class was asked slightly more structured, close-ended questions of the type the data terminals facilitate, the rise failed to compensate for the loss of the 47.6 open-ended questions the teachers asked the average conventional class. And there were no student-initiated questions or student-to-student interactions over the cable in the first round.[2]

The shock was that only ten students had enrolled. In the City of Spartanburg, 62 percent of the adults have not completed their high school education. The evidence collected in the planning stage of the project suggested that many adults dropped out because of lack of transportation, or the need to take care of children at home. Cable had been assumed to circumvent these barriers. The first hypothesis was that a program may need time to win acceptance and we assumed that enrollment would grow.

The first class size comprised our ability to reach conclusions on the test data, but the results were encouraging. The two classes had made roughly equivalent gains despite the differences in the teaching process. Of the ten students that started the cable class, all were sufficiently motivated to complete the 180 hours of instruction despite the lowered levels of interaction and the absence of personal contact. Moreover, as measured by the Adult Basic Learning Examination, their progress was comparable to that achieved by the 13 of 25 students that completed the full series of conventional classes. There was, of course, the usual problem of interpretation because the students were unavoidably aware of their uniqueness as participants in the first class of its kind, and special attention effects may have also played a motivating role.

In this case, the decision was made to keep the second experiment relatively constant. As best we could tell from the ABLE, the basic concept was effective. Now faced with the danger that our student samples

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[2] Student use of data terminals to signal a request for a change in the pace of the lecture or for a review were not coded since, among other problems, it is not clear if that is equivalent to verbal or non-verbal signals in the average discussion. In the second round when a telephone was available the students could initiate verbal questions.

would be much too small, we decided to repeat the program. Since the teachers, curriculum, technology, and goals were the same, we planned to pool the student data if the student numbers continued to be small. Using the classroom observation data, we would try to improve teacher performance using the technology, even though this action would mean that there would be some differences in the class dynamics between the first and subsequent experiments.

Adjusting Teacher Style in a New Media Environment

When the teachers were shown the results of the first round of observation data, they were surprised by the magnitude of the differences in the pedagogical process in the cable and traditional classrooms. In particular, they agreed that far too much of the cable class time had been spent in individual work while too little time had been devoted to substantive drill. As they reflected on the reasons for the disparity in their classroom behavior, it became evident that the absence of nonverbal cues from students in the cable condition was leading them to prolong the work periods. In both the classroom and cable class, students could indicate when they had completed their assignment, but in the classroom the students could then exert substantial, largely non-verbal pressure on the teacher to move on. Thus the teacher was waiting longer for the slower students in the cable environment. In addition, the teachers agreed to put more emphasis on drill. The potential of the technology to involve all of a class in answering questions was more evident, and the teachers felt that this strength of the interactive system should be used more fully.

In the fall of 1976, the GED class was offered again along with other interactive cable programs. The class was again small, and the only technical change was that the cable students were permitted to use their home telephones to call in during class. Data were collected for the GED cable class during eleven 90-minute observation periods over the 15-week period. The results showed that the teachers did adjust their teaching styles to make better use of the technology.

The data for the spring and fall classes for the math and language teachers illustrates the nature of the changes (see Table 2). In the spring the mathematics teacher had spent almost two-thirds of her time

Table 2

DISTRIBUTION OF ACTIVITIES AND INTERACTIONS BY TEACHER AND CONDITION

Distribution of Activity Time	Mathematics			English Language		
	Classroom	Cable		Classroom	Cable	
	Spring	Spring	Fall	Spring	Spring	Fall
Teacher Substantive Presentation	16.4%	18.5%	24.3%	0.0%	11.8%	20.9%
Classroom Substantive Discussion	22.7	0.0	0.0	26.5	0.0	0.0
Individual Work	30.7	65.9	49.0	32.3	54.2	42.3
Drill Activities	13.0	9.8	17.5	37.5	27.1	24.6
Procedural Information	6.7	5.8	6.5	3.7	6.9	5.3
Equipment Adjustment	0.0	0.0	1.6	0.0	0.0	0.6
Teacher Works with Subgroup	1.7	0.0	0.0	0.0	0.0	0.0
Nondesignated Activity	8.8	0.0	1.1	0.0	0.0	6.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Frequency of Interaction per Class						
Closed-ended Questions	2.1	5.7	32.5	32.4	35.6	41.6
Open-ended Questions	39.2	0.0	0.0	50.3	0.0	1.4
Questions about Understanding	34.1	19.8	9.8	92.6	3.1	6.8
Procedural Questions	14.5	8.8	24.0	4.6	21.9	25.1
Total Frequencies	89.9	34.3	66.3	179.9	60.6	74.9
Total Minutes of Observation	211	205	423	136	144	333

with individual work periods on the cable, whereas less than a third of her classroom time had been devoted to individual work. In the fall she gave half the cable class time to individual work, and reallocated the time gained to drill. That shift, coupled with increased requests that students signal their answers to exercises, doubled the average number of teacher-initiated interactions. The math teacher asked her second cable class to respond to closed-ended questions 32.5 times per class, or every three minutes.

Examining the findings for the language class, we see that in the spring the teacher used classroom substantive discussion and drill for presenting material in the classroom. This was also captured in the interaction record, which showed that she was rapidly moving through an average of 180 queries per class. In the cable class she had used relatively more time for lecture (11.8 percent) and individual work periods (54.2 percent as compared with 32.3 percent) as well as devoting less time to drill over the cable. In the spring class she too decreased the amount of time devoted to individual study by being more self-conscious about the absence of cues to move on. The time saved in her class was invested in lecture, increasing that activity to 20.9 percent of her class time.

Taken as a whole, these findings indicated that classroom observation data can be useful in helping teachers become aware of their teaching styles. In addition, the data indicate that teachers, once aware of the pedagogical characteristics of their class, are able to alter their teaching behaviors to better reflect their own notions of how a class should proceed.

Seeking Explanations for Student Achievement

The results of the second class again found that students attending the electronic classroom made satisfactory gains. In looking at the classroom dynamics from that perspective, several explanations begin to emerge. Although there is a substantial loss of class discussion and open-ended questions in the cable class, the conventional classroom does not spend time in student dominated discussion, rarely does the teacher walk around the class to work with individual students, and the students initiate very few questions. The observation data shows that the teachers in the conventional class do not take full advantage of the range of educational arrangements possible in the regular classroom environment, but not available on cable. Thus, the absence of significant differences in educational achievement may reflect the fact that, in actuality, the pedagogical differences between the two conditions may not have been as great as might have been expected.

Another explanation comes from considering the different consequence of a closed-ended question in the two environments. Although these data seem to indicate that students in the cable classroom engage in much less interactive activity than those in the conventional class, this difference may be more apparent than real. When a teacher asks a question in a conventional classroom, only one or two students need to respond. The other students are not required to focus on the question, choose an answer, and receive reinforcement. In the cable classroom with home data terminals, every student in the class answers each question independently, without guidance or cues from others. Particularly for passive students, the nature and effect of this structuring of student attention and participation may be a key to the success of the electronic classroom.

Results of the Serial Design

When a serial design is used, the researcher can make the best of several worlds. It is a prudent strategy which can allow serious restructuring of the project without sacrificing evaluation. When the concept works as it did in Spartanburg, the data gives one confidence to leave well enough alone. But there are other advantages.

The first and more obvious opportunity is that one can pool the data. In all, we offered the GED course in Spartanburg three times. We had 10, 12, and 11 enroll in the course, and fewer took the ABLE posttest. If we had not had several experiments, kept them constant in terms of teachers, curriculum, and technology, and been able to pool the data, the conclusions would have been lame and tentative. The comparison group of students taught by the same teachers, using the same workloads and lectures, adds to our ability to reach a confident conclusion. The students in the electronic classroom learned as much as the students in the conventional class. Using mean percentile ranks on the ABLE as a criterion, we see on Table 3 that when the cable class began, they were weaker students. But they essentially held pace, and were just behind the conventional class on the posttest. Using percent gain as a criterion, they made similar progress. The dropout rate was slightly higher in the cable class, particularly in the last class when serious technical problems plagued the system. Thus there is the possibility that more weak students dropped from the cable class, artificially enhancing the average gains based on the posttest. Even so, that is not likely to be a strong enough factor to alter the basic conclusion: the proportionate gains of the cable were not statistically different from the conventional classroom.

The conclusions of the Spartanburg project support efforts to replicate the electronic classroom concept for home education. Since the basic communications functions of the system are outbound audio-video and return data, it seems clear that the approach could use broadcast television and telephone return and other technology mixes as alternatives to two-way cable. We know that the teachers can, with limited initial training, adjust their teaching styles to the electronic environment, and something about the problems that will arise when teachers are cut off from visual cues about their class. Such classes are probably equivalent to classroom instruction as it normally exists, even if they cannot provide instruction as good as that in the ideal class.

More generally, we found that the use of a serial design has many advantages and would strongly recommend it for future field work. Serial experiments, with both process and outcome measures, and a standard of comparison served the combined purposes of the management of innovation and research on its effects. The broad conclusion is that the use of serial designs and a more creative approach to communications system evaluation will increase the value of research for the manager. That, in turn, creates incentives for more controlled management of the project, enabling the evaluator to do better research.

Table 3

STUDENT ACHIEVEMENT ON ADULT BASIC LEARNING EXAMINATION
(mean percentile ranks)

ABLE	Conventional	Cable Class
Pretest	(n=38)	(n=29)
Vocabulary	48.9	42.2
Reading	56.2	45.6
Computation	44.6	23.6
Problems	40.9	35.6
Spelling	53.5	49.8
Posttest	(n=32)	(n=21)
Vocabulary	55.2	62.0
Reading	68.0	69.5
Computation	71.8	54.1
Problems	60.4	50.6
Spelling	61.7	56.0
Gain (% of increase from pre to post)	(n=21)	(n=21)
Vocabulary	7.4	16.1
Reading	18.3	19.0
Computation	25.3	28.0
Problems	12.7	16.8
Spelling	10.4	5.3